

Since the conversion factor from micromhos to TDS is unknown and must be adjusted for different boiler waters

and condensate. Reference appendix B, paragraph B02e for conductivity test procedure for boiler water.

SECTION III. OPERATION

4-9. BOILER WATER TREATMENT OPERATING LOG

An example of the monthly Repair and Utilities Operating Log (Boiler Water Treatment), DA Form 4367, is shown in figure 4-21. Regulation requires this log to be maintained in plants operating above 15 psig steam or 300 psig water with an output capacity above 3.5 MBtu/hr or 100 horsepower. This log provides a record of boiler, makeup and condensate water treatment and test results. The data obtained from this log makes an accurate analysis of plant operation possible. Entries are made in columns. An explanation on the use of each column is on the back of the form. One log should be maintained for each boiler and one for plant makeup water data. Columns 19 and 20 may be used to record condensate conductivity and hardness. If a boiler is secured in a wet condition, causticity and sodium sulfite residual should be indicated in the remarks block. If the boiler is secured dry, the frequency of desiccant inspection should be indicated. Organized operating logs should also be maintained for low pressure boilers and for HTW, MTW, and LTW systems. The logs should contain the following information: results of all chemical tests, dates tests performed, amounts of chemicals added, dates chemicals added, and amount and time blowdown performed. Periods of boiler layup and downtime maintenance should also be recorded.

4-10. PROCUREMENT OF STANDARD AND SPECIAL TREATMENT CHEMICALS

Prescribed chemicals for boiler plant water conditioning may be procured as listed below.

a. Caustic Soda. Specify: "Caustic soda for boiler feedwater treatment; to contain not less than 76 percent sodium oxide (Na_2O) and be in flake form." As it absorbs moisture readily and becomes sticky, specify shipment of the chemical in 100-pound steel drums. This chemical may be procured from commercial sources.

b. Sodium Phosphate. Sodium phosphates may be specified with reference to table 4-4. Example: For sodium metaphosphate specify "Compound, boiler feed water, Type II sodium phosphate, glassy, 67 percent P_2O_5 ." The chemical is shipped in 100-pound bags and may be procured from the Federal Supply Schedule.

c. Quebracho Tannin. Specify: "Quebracho tannin, solid, for boiler feedwater conditioning; suitably processed to obtain easy solubility; shall be of the following composition:

shall contain not less than 65 percent quebracho tannin, not more than 17 percent non-tannin, nor more than 1 percent insoluble, and not more than 20 percent water; packed in 100-pound bags." This chemical may also be procured from the Federal Supply Schedule.

d. Sodium Sulfite. Specify: "Sodium sulfite (Na_2SO_3), anhydrous, for boiler feedwater treatment; to contain at least 90 percent Na_2SO_3 , the remainder to be primarily sodium sulfate (Na_2SO_4), sodium carbonate (Na_2CO_3), with less than 1 percent moisture; a 10 percent solution to be alkaline to phenolphthalein."

e. Antifoams. For antifoam or other special water treatment chemicals, consult the operating agency commander for the proper chemical to use and the correct method of application.

f. Rock Salt. A good grade of rock salt is preferable to granulated salt for regeneration purposes. Rock salt does not cake, as do many grades of granulated salt, and it is equally effective as a regenerating agent. The salt should contain not less than 98 percent sodium chloride with a minimum of calcium and magnesium salts, contain less than 1.5 percent of dirt or other insoluble matter, and have a grain size within the 10 to 50 mesh range.

g. Morpholine. Specify "Morpholine ($\text{C}_4\text{H}_9\text{NO}$), boiler feedwater compound, used to control carbon dioxide corrosion in steam condensate lines; 40 percent morpholine content; all drums to bear adequate caution labels to protect against fire, poison, and caustic burn hazards; packed in 480 pound drums (55 gallon drums)." Available from the Federal Supply Schedule.

h. Cyclohexylamine. Specify "Cyclohexylamine ($\text{C}_6\text{H}_{11}\text{NH}_2$) boiler feedwater compound, used to control carbon dioxide corrosion in steam condensate lines; 40 percent cyclohexylamine content; all drums to bear adequate caution labels to protect against fire, poison, and caustic burn hazards; packed in 420 pound drums (55 gallon drums) or packed in 40 pound drums (5 gallon drums)." Available from the Federal Supply Schedule.

i. Proprietary Compounds. As a general policy, use of premixed chemical compounds is not authorized. Such compounds, if proportioned correctly for a specific water, generally cannot be used advantageously without change for water of a different analysis. As the boiler compound is a fixed mixture of chemicals, there is no way to adjust the dosages of individual chemicals for maintaining the desired concentrations of each in the boiler. Exceptions

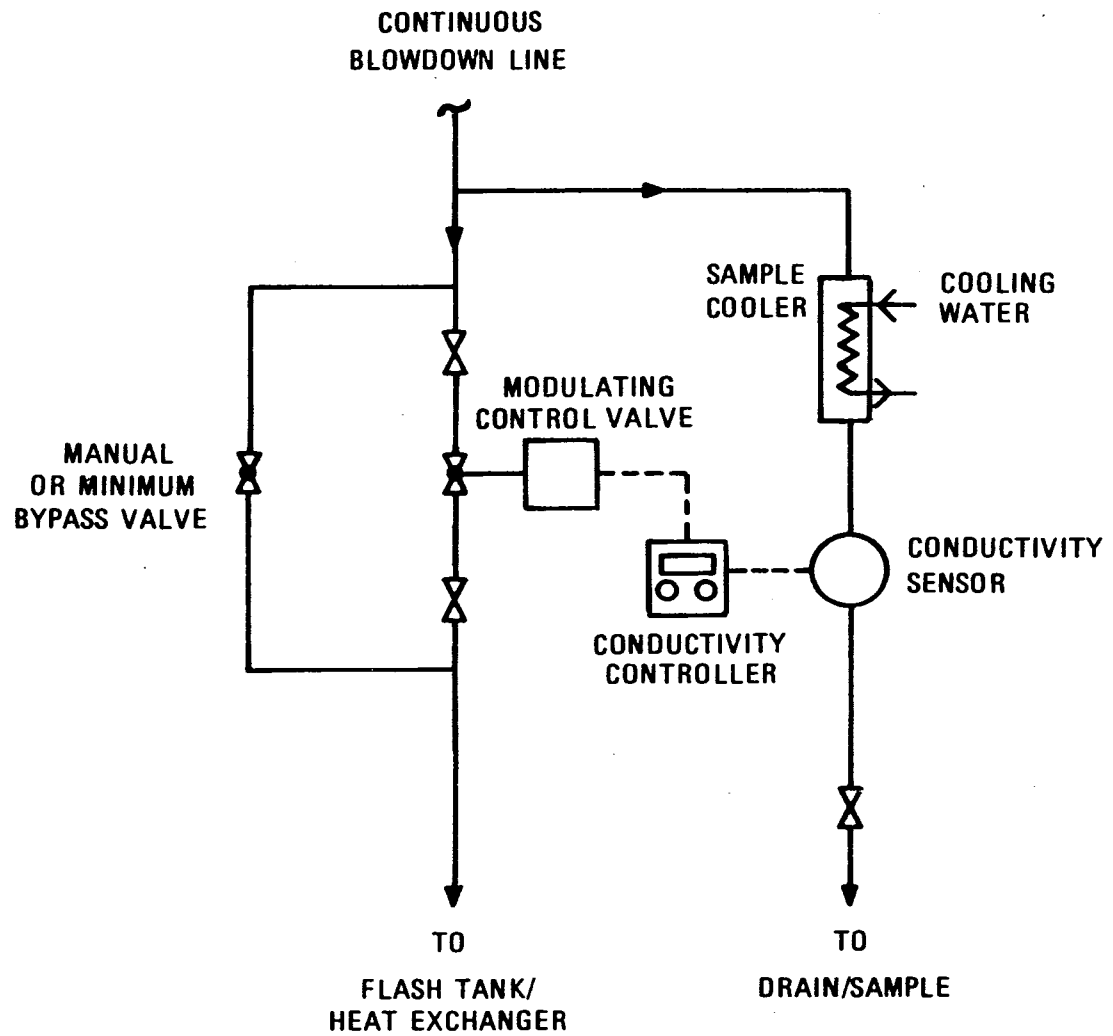


FIGURE 4-19. AUTOMATIC CONTINUOUS BLOWDOWN CONTROLS



FIGURE 4-20. CONDUCTIVITY METER

[illegible]

FIGURE 4-21. BOILER WATER TREATMENT
OPERATING LOG

may be authorized by Office Chief of Engineers. Also, exceptions are made in the use of proprietary briquettes for power plant water conditioning in a theater of operations.

j. Magnetic and Electromagnetic Descaling Devices. A variety of magnetic and electromagnetic devices are currently manufactured that claim to reduce both corrosion and scale with substantially no technical control. Several commercial units were evaluated under field and laboratory conditions. These tests did not provide any indication that the devices were effective in preventing or reducing scale, or in improving boiler efficiency. Army-wide use of magnetic descalers is not recommended, based on these findings. Moreover, current operation of such devices at Army facilities should be quantified and validated.

4-11. CARE AND MIXING OF TREATMENT CHEMICALS

Chemicals are received in a dry state, and must be properly stored to prevent contamination and absorption of water. Precautions must be taken in mixing and handling chemicals to ensure that accurate quantities are used, and to prevent contact with chemicals which could cause injury.

a. Storage. Store all chemicals in a dry place, at floor level, free from contact with foreign substances.

b. General Precautions. Avoid getting chemicals on the skin. Wear work gloves and eye protection while handling chemicals, either in dry form or in solution. Add chemical solutions to the feeding device immediately after preparation. The use of a properly designed screen to remove foreign material from the solution before feeding is desirable to prevent line stoppages. If chemicals such as flake caustic contact the skin, they must be rinsed with large quantities of water. If any chemical solutions splash in the eyes, rinse immediately with large quantities of water. Refer to paragraph 4-18 for additional safety precautions.

c. Methods of Mixing/Makeup of Chemical Dosage.

CAUTION

Mix chemicals at floor level or in an approved open feeder to avoid injury to eyes or face.

Do not mix batches of chemicals in advance of immediate requirements, as this defeats the purpose of the treatment and complicates control of the individual chemical concentrations in the boiler water. Individual chemicals are used in boiler water treatment rather than ready-mixed compounds because they permit better control of concentration. Improper chemical concentrations are not effective in protecting the internal water-contacted surfaces of the boiler against scale and corrosion. A chemical analysis of boiler water should be made so that the chemical demand of the water may be determined. The treatment

requirements are described in paragraph 4-5.

(1) Solution of Tannin and Phosphate. Tannin is dissolved in hot water at approximately 160° F to 180° F in a clean metal container. Stir until the tannin is completely dissolved. Mix phosphate separately in water at approximately 150° F in a clean metal container, and stir until all phosphate is dissolved. Mix the two solutions before placing in chemical feeding device.

(2) Solution of Caustic Soda.

CAUTION

Do not use hot water for the solution of caustic soda, as splashing and possible serious injury will result. Wear goggles and rubber gloves when mixing this chemical. Do not pour cold water on caustic soda as splashing and possible serious injury can result. Add the caustic soda gradually, with constant stirring, to an adequate quantity of cold water.

(3) Solution of Sodium Sulfite. Mix sodium sulfite solution just before use in cold water and with minimum exposure to air. If mixed too soon, the chemical is useless for boiler water treatment because it will react with oxygen from the air which dissolves in the solution. Use the minimum amount of mixing to dissolve the chemical.

4-12. INITIAL FLUSHING AND CLEANING

Contracts for installation of new boilers generally require removal of all foreign material followed by an initial boiling-out period with a chemical solution. If chemical cleaning is considered necessary after acceptance of the boiler, follow the steps below.

a. Before the boiling-out procedure has begun, replace high pressure gage glasses with temporary glasses to prevent attack on the glass by the boil-out mixture.

b. Chemicals in the following proportions should be thoroughly dissolved in the water before being placed in the boilers:

24 pounds caustic soda
24 pounds disodium phosphate (anhydrous)
8 pounds sodium nitrate
½ pound suitable wetting agent

1,000 gallons water

c. Fill the boiler with the above solution and operate at approximately 30 to 50 psig for a period of 24 to 48 hours, exhausting the steam to atmosphere.

d. Open and drain the boiler. Remove any loose material.

e. Flush the boiler thoroughly to ensure that none of the chemicals used in the boiling-out process remain in the boiler.

f. To remove oily residue which will cause foaming in the boiler water and contamination of steam, provide

adequate blowdown during the first week of boiler operation.

4-13. FLUSHING AND CLEANING OF SCALED AND CORRODED BOILERS

Many used boilers are scaled and corroded upon installation. If corrosion appears to be serious, make an immediate boiler inspection. If the scale is moderate or light, remove as follows:

a. Clean out all loose scale, and any scale adhering to the boiler which can be removed manually.

b. Place in the boiler approximately 15 pounds of caustic soda and 10 pounds of phosphate for each 100 horsepower or 3450 pounds of steam per hour boiler capacity. Seal the boiler openings and open all vents. Fill the boiler approximately three-quarters full with water.

c. Use a small fire in the furnace and raise the temperature of the water in the boiler to approximately 200° F. Maintain this temperature for 24 to 48 hours. Add makeup water as required during this period to fill the boiler to the base of the safety valves.

d. Analyze the boiler water during the boil-out period and add caustic soda and metaphosphate to maintain the following concentrations:

Hydroxide: 300 to 500 ppm

Phosphate: 100 to 150 ppm

e. Open the boiler at the end of the boil-out period and clean out the sludge and loose scale. Pay particular attention to removing scale and sludge from water legs in fire-tube boilers. Flush the boiler thoroughly.

f. If, at the end of the boil-out period, inspection shows that heavy or hard scale was not removed, use of an acid to remove the scale is indicated. Notify the operating agency commander. Due to the hazards involved and the possibility of damage to the boiler when acid cleaning large steel boilers, use firms specializing in this type of work.

g. If extensive corrosion is exposed when scale is removed, have a boiler inspection made by an approved agency.

h. When the boiler is operated, any residual scale may cause faulty operation. Sufficient and frequent blowdown must be used to maintain dissolved solids at a maximum of 3,500 ppm. Take the boiler out of service at frequent intervals to remove sludges formed from disintegrated scale.

4-14. SAMPLING

Samples are obtained and tested so that treatment chemicals can be maintained within proper limits and blowdown can be controlled. The samples should be representative of the water to be tested. This can be accomplished by using proper sampling points and methods. All samples must be drawn before chemicals are

added to determine the minimum concentrations of the chemicals available in the boiler. Samples must be drawn before the bottom is blown down to determine the maximum total dissolved solids content of the boiler water.

a. **Samples for Check Analysis.** Army Regulation 420-49 requires samples to be submitted to an adequately equipped laboratory for check analysis. The samples are submitted to assist operating personnel in correcting faulty analytical techniques, in providing a quality check of reagents, and in making available a basis for evaluation of compliance with residual requirements. The USAEHSC Laboratory, Fort Belvoir, Virginia, performs the check analyses on samples submitted from Army installations. In overseas commands where shipment of samples to the United States is not feasible or expeditious, samples will be sent to a central laboratory established by the command. Reports on sample analyses are returned through command channels and include appropriate technical comments.

(1) Each operating boiler plant equipped with hot water or steam boilers with one or more boilers of 3.5 MBtu/hr or 100 horsepower or greater capacity must submit a sample for check analysis each month.

(2) Each operating boiler plant equipped with hot water or steam boilers of less than 3.5 MBtu/hr or 100 horsepower capacity shall submit a sample for check analysis once every three months.

(3) Submit a 32-ounce sample for all high pressure (15 psig or greater) boilers and low pressure boilers treated with caustic, phosphate, tannin, and sodium sulfite.

(4) Submit a 4-ounce sample for low pressure boilers (less than 15 psig) treated with caustic only.

(5) Submit a 32-ounce sample for hot water boilers.

(6) Sample shipping containers and bottles for submission of boiler water for check analyses are obtained by direct request to USAEHSC. In overseas areas when the command has established a central laboratory for the analysis of boiler water, sample containers and bottles should be obtained from that source. Containers for high-pressure boiler water samples are designed to ship a 32-ounce plastic bottle. Containers for water samples from low-pressure boilers treated with caustic soda are designed to ship a 4-ounce plastic bottle. Pack the bottle carefully so that it will not leak in shipment. A data sheet is enclosed in each sample container. Completely fill out the data sheet and ship it with the sample.

b. **Water Sample Collection.** A water sample should be drawn through a cooling coil that prevents the flashing of the boiler water into steam. An air-cooled coil can be used if the sample is drawn slowly, but best results are obtained by using a water-cooled coil such as the one shown in figure 4-22. If boiler water is taken without cooling, it becomes concentrated because a portion of the water flashes into steam. Blowdown based on the testing of a

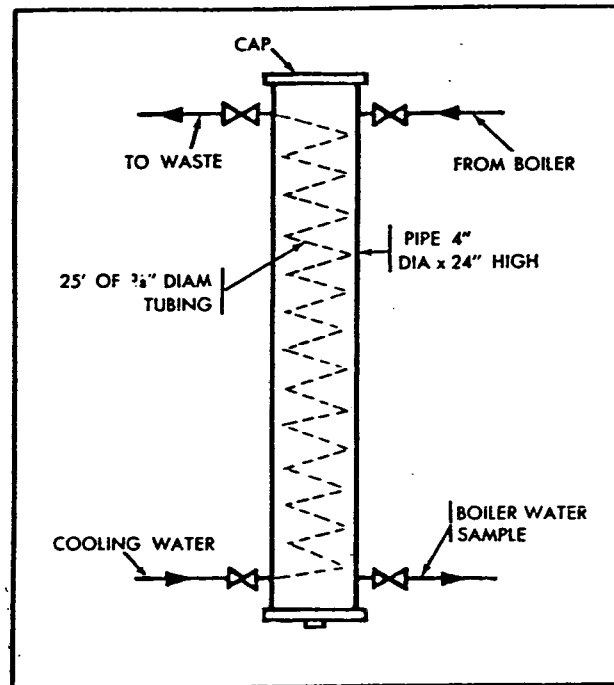


FIGURE 4-22. WATER COOLED SAMPLE COOLER

concentrated sample will be too high, resulting in unnecessary chemical and energy costs. It is important to flush the sample line and cooler thoroughly before taking a sample.

c. Location and Sizing of Lines. Use the manufacturer-supplied sample connection when provided. Water column connections may be used if sample connections are not provided. Blow the water column down several times and draw a sample from a 1/4-inch sampling connection installed ahead of the water column blowdown valve. Properly located continuous blowdown connections can also make good sampling points. If the sample connection is close to the feedwater inlet, be sure that the sample is not diluted by feedwater. Pipe all sample connections to floor level for convenience and safety. Connect the sample cooler to the sample line. It is desirable to locate the sample cooler near the laboratory sink where tests for boiler water residuals are made.

d. Steam Sampling Nozzle. A separate steam sampling nozzle is desirable to ensure that a representative sample is obtained from each individual boiler. The nozzle and method of connection should conform to the American Society for Testing and Materials (ASTM) Method D1066. A sample cooler other than the one used for sampling boiler water must be used for steam sampling because of the possibility of collecting residual boiler water solids. All piping, connections, and valves conveying the steam to the sample cooler must be corrosion-resisting material, such as copper, brass, or stainless steel. The steam sample is taken in the following manner:

- (1) Flush the sample line and cooler thoroughly. Flush out new steam sampling equipment for 24 hours before using it to collect steam samples.

- (2) Draw the sample slowly and bring it to about 70° F (unless the test calls for a higher temperature) by regulating the flow of cooling water.

- (3) Rinse the collecting container at least three times with the sampling water before collecting the sample.

- (4) Collect about a pint (500 ml) of sample in a thoroughly cleaned glass container. Note that a sample of steam drawn when the velocity of the steam in the main is high is more representative than a sample drawn when the velocity is low.

4-15. CHEMICAL ANALYSIS

The chemical analysis performed on boiler water has the purpose of accurately determining the chemical makeup of the water. Accurate analysis is important step in protecting equipment from excessive corrosion and scale, and at the same time maintaining the most economic production of steam or hot water.

a. Authority for Tests. Test kits and analysis equipment

are provided by the Army for regular use with each boiler. The equipment and tests have been developed by the boiler manufacturers and government chemical analysis laboratories to give accurate and timely information on boiler water conditions that are unique to each installation. There may be other tests for a given parameter of boiler performance; however, a good general rule is, "If the equipment and the test procedures are not discussed by this manual, THE TEST IS NOT AUTHORIZED." Other procedures may be too costly or time-consuming to perform on a regular basis and the results of such unauthorized tests can require an extraordinary level of training for proper interpretation.

b. Test Scheduling. Tests should be run according to the schedule below. The procedures for these tests are outlined in appendix B.

- (1) **Boiler Water.** All boilers of 100 horsepower or more are tested daily. Boilers less than 100 horsepower are tested twice weekly, or more often if necessary to maintain the specified chemical limits. High pressure steam boilers are tested for causticity, phosphate, tannin, sodium sulfite, and conductivity. Low pressure steam boilers treated for corrosion with caustic soda only are tested for pH and conductivity. Hot water boilers are also tested daily, for pH, hardness, and sodium sulfite. LTW boilers are tested for nitrite. Boiler water samples from all hot water and steam boilers are submitted to the USAEHSC Laboratory for check analysis at intervals specified in paragraph 4-14a.

- (2) **Condensate.** Condensate is sampled daily at its return to the plant and weekly at the end and midpoint of the distribution system. The parameters tested are pH and conductivity. Hardness is tested if a change in conductivity is noticed, or routine hardness testing may be substituted for conductivity testing. Hardness indicates a leakage of raw water into the system. This leakage must be found and corrected.

- (3) **External Treatment Plants.** Water samples from external treatment plants should be tested daily (each operating unit) or more frequently based on manufacturer's instructions. The parameters tested are hardness, free mineral acidity, and/or alkalinity, depending upon the particular equipment. The operating pressure and temperature of all deaerator units should be checked and recorded once a shift, and adjustments made, if required.

c. Instrumentation. Instrumentation has been developed which can accurately, reliably, and continuously monitor the conductivity of boiler water. This instrumentation is economical for testing and for use in continuous steam boiler blowdown systems to control dissolved and suspended solids. Daily testing of conductivity is still required. Reference paragraph 4-8b which discusses conductivity meters.

d. Special Corrosion Testing. Corrosion testing assemblies are installed at various points in the condensate system for three month test periods to study corrosion. Tests should be performed once a year in each condensate system. The corrosion coupons, which are machined and weighed prior to installation, are removed at the end of the test and forwarded to USAEHSC for analysis. Loss of weight, thickness, and amount of channeling and pitting are measured and general appearance is evaluated. USAEHSC then prepares a report noting corrosion rates of the piping tested and recommending changes in water treatment procedures. Reference figure 4-23 which shows the corrosion tester. The USAEHSC form supplied with the corrosion tester should be completely filled out and returned with the coupons.

4-16. GENERAL OPERATION OF EXTERNAL TREATMENT EQUIPMENT

Complete operational instructions for external treatment equipment are contained in the manufacturer's manuals. The following information should not be regarded as a substitute for the individual manufacturer's instructions.

a. Zeolite Softeners. For proper operation of all softening units, post the manufacturer's instructions conspicuously near the softening units. Follow these instructions in the regeneration, rinse, and operation of these units. Keep a careful record of salt consumption of the softeners, and periodically compare this consumption to that specified by the manufacturer. Salt consumption per unit volume of water softened is an excellent index of softener performance. An increase in the quantity of salt used between regenerations of a given unit indicates a deterioration in performance.

(1) Rates of Flow. To obtain continued satisfactory performance of zeolite treatment equipment, it is essential that flow rates be maintained at all times within the limits set by the manufacturer. Figure 4-24 illustrates schematically the normal up- and down-flows of a zeolite unit. The down-flow represents the service, regenerant solution, and rinsing flows; the up-flow represents the backwash.

(a) Service Flow. When the recommended service flow rate is exceeded, both excessive pressure drop and loss of impurity removal efficiency occur. These are the results of forcing the water to channel through the paths of least resistance in the softener material, thereby reducing the necessary contact with the zeolite. Reference figure 4-25 which illustrates the effects of excessive flow rates.

(b) Backwash Flow. In this operation, the zeolite bed is raised so that the individual grains of zeolite are suspended in water. Packing of the bed which may have occurred during the service operation is broken up, and dirt or other foreign matter that may have collected on

top of the bed is washed out. If the backwash rate is too low, the packing is not broken up and the zeolite bed is not properly suspended. Under these conditions, the fine foreign material and dirt do not wash out of the bed. Fine particles, if not washed out of the bed, act as an abrasive on the zeolite grains. The abrasive action may cause the zeolite grains to break up, leading to increased pressure drop and breakthrough in subsequent washings. If this occurs, the entire contents of the unit may have to be removed, the gravel regraded, and the bed relaid. Backwashing at an insufficient rate of flow over an extended period does not accomplish the desired results because, even though the water to waste appears fairly clear, only the dirt and fines capable of being lifted by a low flow rate are removed, while other objectionable heavier particles remain. If the wash rate is too high, the zeolite washes out, reducing the capacity of the unit. Backwashing for too short a period does not complete the operation, because a minimum length of time and volume of water are required to lift the zeolite before the zeolite fines and other foreign matter are removed. Backwashing for too long a period at the proper flow rate is a waste of water. Care must be taken to avoid sudden shocks to the bed while backwashing. Shocks may be caused by water entering the unit too rapidly, by pumps being started while the unit is backwashing, or by bubbles of air entering the unit. Any of these may cause gravel hills or upsetting of the bed.

(c) Regenerant Solution Flow. In this operation, the impurities attached to or combined with the zeolite are removed, and the zeolite is reactivated by passing a regenerant solution through the bed. The solution enters through the distribution laterals at the top of the unit, passes through the bed and leaves at the bottom. Its strength, whether made up of brine, sulfuric acid, or caustic soda, is most important, and the manufacturer's instructions for preparation must be followed. If the proper solution strength or solution volume is not maintained, the unit will operate at reduced capacity.

(d) Rinse Flow. To obtain the correct rate of flow, the rinse flow control device must operate freely and be adjusted in accordance with the manufacturer's instructions. If the rinse rate is too high, the bed tends to pack. If the rate is too low, the rinse time is prolonged, or the excess regenerant solution and impurities are not properly washed out.

(2) Check for Efficiency. After the zeolite unit has been installed, the installing contractor will test it for performance. The quantity of treated water that a unit can deliver can be easily checked if the exchange capacity and the number of cubic feet of zeolite contained in the softening unit are known. For example:

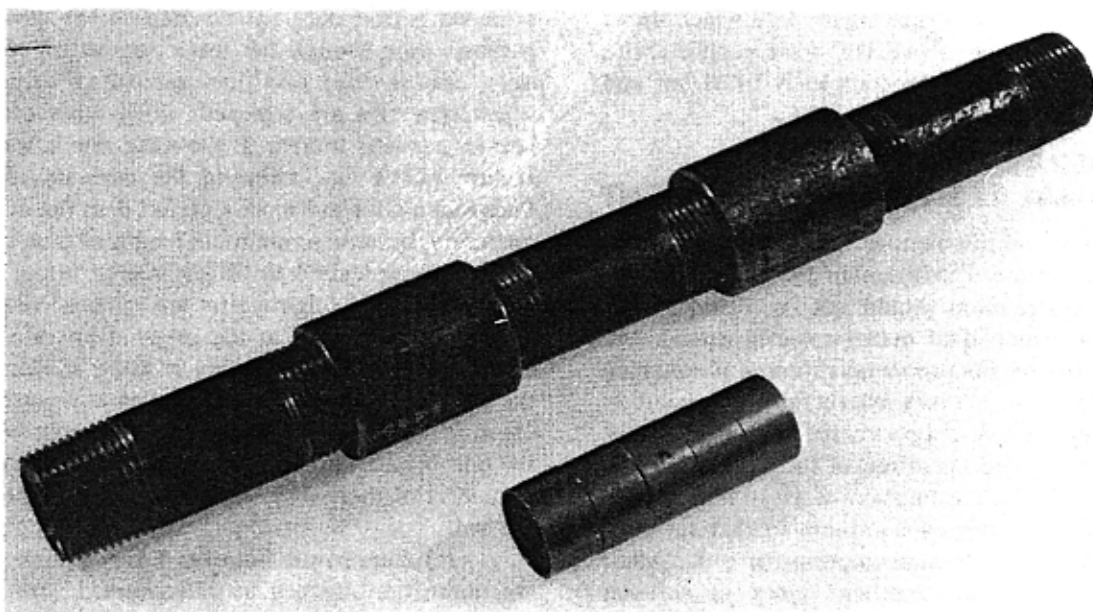


FIGURE 4-23. CONDENSATE CORROSION TESTER

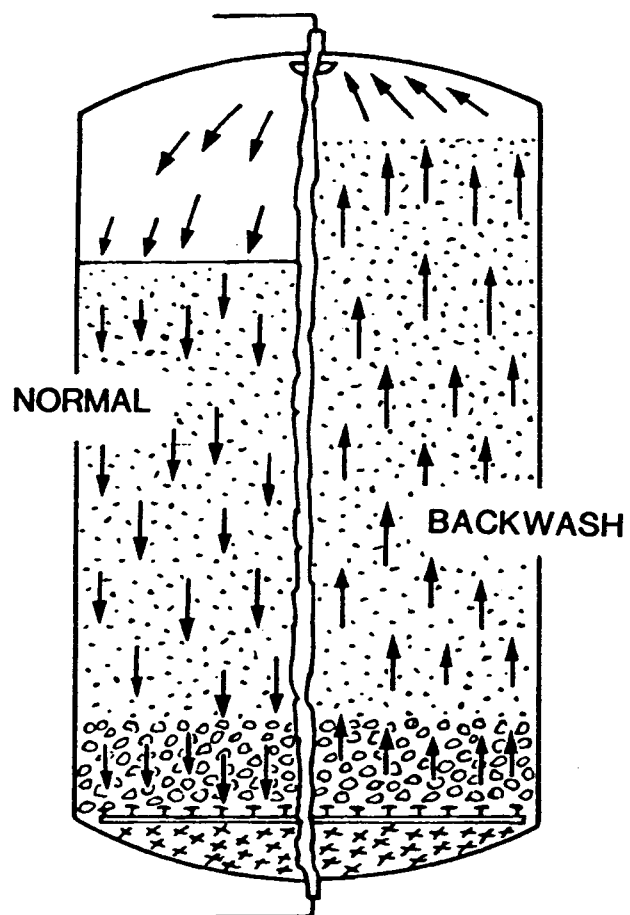


FIGURE 4-24. ZEOLITE SOFTENER WATER FLOWS

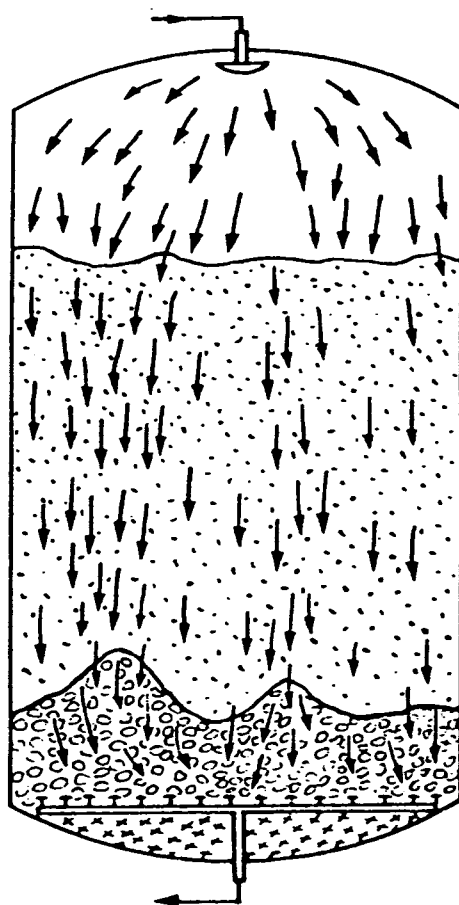


FIGURE 4-25. EFFECT OF EXCESSIVE WATER FLOW RATES

$$\text{Capacity (gallons)} = \frac{\text{Cubic Feet of Zeolite} \times \text{Exchange Capacity of Zeolite in Grains per Cubic Foot}}{\text{Hardness of Water as CaCO}_3 \text{ in Grains per Gallon}}$$

If a sodium zeolite unit has an exchange capacity of 250,000 grains and the raw water has a hardness of 10 grains per gallon, the unit can soften $250,000/10 = 25,000$ gallons between regenerations. If the unit requires regeneration after softening 20,000 gallons with the same 10 grain hardness water, the unit's efficiency is then $20,000/25,000 \times 100 = 80$ percent. But, if the raw water analysis shows a change, such that its hardness is increased from 10 grains to 12.5 grains, then 20,000 gallons softened between regenerations shows no loss in efficiency because $250,000/12.5 = 20,000$ gallons. It is necessary to check softener efficiency periodically. If it shows a marked decrease, the operator should go through the foregoing procedure to determine if the loss in efficiency is due to a change in the raw water analysis. If it is due to other factors, the flow rates during service and regeneration should be checked to determine if the recommended rates are being properly maintained. The surface of the zeolite should also be checked. A hilly appearance gives evidence of channeling and packing of the bed and furnishes a clue to the condition of the gravel bed surface beneath. A check on the depth of the zeolite bed indicates whether zeolite has been washed out. Measurements should be taken at several points to assure an average depth. They are taken by inserting a small-diameter rod or a 6-foot metal rule through the zeolite until the gravel is felt and then noting the distance the rod or rule was inserted. Make probings at approximately the points indicated in figure 4-26, and enter the measurements in the corresponding circles. Another way to determine the depth is by comparative measurements of the distance from the zeolite surface to the backwash and brine distributor fittings or some other fixed point. If a loss of zeolite material is evident, the cause must be found and the zeolite replenished, with care taken to avoid repetition of the loss. In addition to washing out, loss may be caused by a defective underdrain system or by a clogged and defective brine distributor system. Another cause may be a change in the water undergoing treatment. Its constituents may be incompatible with the zeolite being used. If the cause of the failure cannot be determined, consult the manufacturer's service representative. When maintenance recommendations fail to correct operational difficulties, refer the matter to the operating agency commander.

(3) **Check of Salt Requirements.** Approximately one-half pound of salt is required per 1,000 grains of hardness removed for each regeneration. The following calculation

is used to determine actual salt consumption of a salt regenerated unit:

$$\text{Salt (NaCl) required (lbs)} = \frac{\text{Gallons of Water Softened} \times \text{Hardness of Water as CaCO}_3 \text{ in Grains per Gallon}}{2,000}$$

A saturated solution of brine, necessary for proper regeneration of a softening unit, has a Baume gravity of 23° and contains 2.5 pounds of salt per gallon.

(4) **Parallel Operation.** Best results and most efficient operation are obtained if all installed units are operated in parallel. Regardless of the load imposed on the softening plant, all units should be operated simultaneously. If more than one softening unit is installed in a plant, regenerations of the units should be staggered.

b. **Hot-Process Lime Soda Softeners.** In the operation of hot-process plants, the following minimum requirements for proper performance must be carefully observed.

(1) **Steam Pressure and Temperature.** A positive steam pressure must be maintained within the reaction and sedimentation tank at all times to ensure venting of oxygen and other non-condensable gases. The minimum water temperature in the sedimentation tank must not be more than 5 to 10° F below the temperature of the steam in the tank. This temperature is necessary to promote softening reactions and to ensure complete settling of the precipitate. When insufficient exhaust steam is available to maintain this temperature, live steam must be supplied and controlled from the steam space so that a positive pressure is maintained within the tank.

(2) **Chemical Control Tests.** Chemical tests must be made regularly in accordance with the manufacturer's recommendations. Satisfactory results cannot be expected if the operator cannot be certain at all times that the water everywhere in the plant is of the best quality obtainable.

(3) **Chemical Tanks.** Chemical tanks must be charged regularly with the correct amounts of the proper chemicals. At the time of charging, the operator must examine the proportioning equipment to ensure that moving parts operate freely.

(4) **Sludge Blowdown.** The sedimentation tank must be blown down regularly, the frequency depending on the character of the raw water. If this practice is not followed, the sludge cone fills with sludge, and an excessive amount of suspended matter can be carried upward into the clarified water zone, overloading the filters.

(5) **Filter Backwash.** The filters must be backwashed regularly to ensure ample hydraulic head on the booster or the boiler feedwater pumps. Proper backwashing will also help to prevent suspended matter from accumulating to the point at which it passes through the filtering material and contaminates the feedwater.

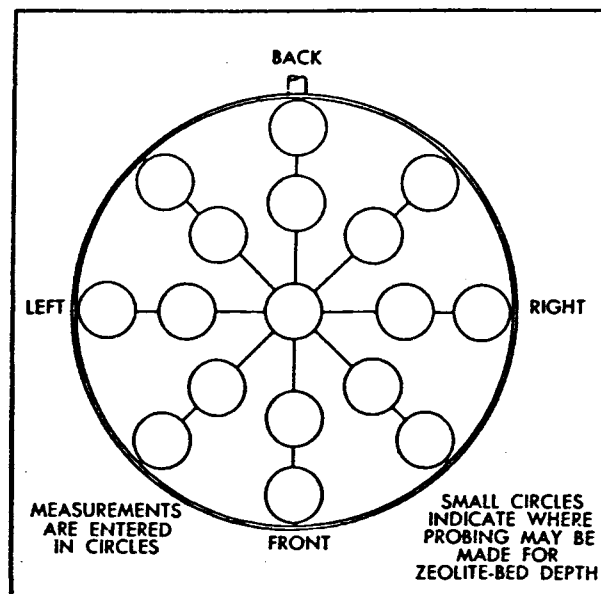


FIGURE 4-26. ZEOLITE BED INSPECTION POINTS

(6) **Overload.** To assure proper operation of the softener and filters in providing a high quality boiler makeup, the rated capacity of the softener must not be exceeded.

c. **Deaerators.** The operating procedure for efficient deaeration involves keeping the deaerator vent open at all times, keeping the live steam regulator on at all times, using as much exhaust steam as possible, maintaining the water at boiling temperature, keeping makeup water to a minimum, cleaning the deaerator at least every six months, checking trap operation on the oil separator daily, and checking the surge tanks and deaerator for overflow due to leaking valves. The reasons for these actions are described in the following subparagraphs. It is important that a properly located and calibrated thermometer and pressure gage be installed on each deaerator. Only with accurate temperature and pressure information is proper deaerator operation possible.

(1) **Relationship of Temperature, Pressure and Solubility.** In order to secure good deaeration, the temperature of the feedwater must be continuously maintained at the saturation temperature corresponding to the steam pressure maintained on the deaerator. The proper relationship between water temperature and the steam pressure is shown in table 4-5. The difference between the saturation temperature (corrected for altitude) and the feedwater temperature should not be more than one degree.

(a) For example, assume the following conditions: a boiler plant located at an elevation of 1,000 feet above sea level, the steam pressure in the deaerator is 2 psig, and the feedwater temperature in the heater storage compartment is 216° F. As indicated in table 4-5, the temperature difference is not more than 1° F; therefore, the heater is efficiently removing dissolved gases. In this example, merely maintaining temperatures above 212° F will not give good deaeration, since a significant amount of oxygen may still be dissolved in the water.

(b) For an example of solubility, assume the following conditions. A deaerator is operating at 7 psig pressure and the feedwater temperature is 218° F. By following the temperature line of figure 4-27 for 212° F vertically up to the 7 psig pressure curve intersection and then moving to the left to the oxygen content table, it is noted that solubility of oxygen under these conditions is 1.8 cc per liter or 2.5 ppm (cc O₂ per liter X 1.4 = ppm O₂). This is too high and indicates inadequate deaeration. Good deaeration should reduce oxygen to between 7 and 40 parts per billion, a thousand times less than in this example. To assure good deaeration, the proper feedwater temperature for 7 psig steam pressure is found to be 233° F (at sea level). It must also be remembered that adequate vent flow must be maintained if optimum deaeration is to be accomplished. See subparagraph (3)

for further information.

(2) **Methods of Maintaining Temperatures.** All possible exhaust steam should be used for deaerator operation. Where a large amount of exhaust steam is available from boiler plant auxiliaries such as fans, turbines, stokers, and pumps, the back pressure should be set as high as the particular installation will permit without causing feedwater pump trouble. Temperatures of 230° to 240° F are not unusual for this type of operation. Live steam regulators or reducing valves are used to supply the necessary steam when sufficient exhaust steam is not available. They should be kept turned on at all times because they use steam only as required. Live steam to a deaerator cannot be controlled by hand due to fluctuating loads; such a procedure would cause either too much or too little steam to be used. Proper deaeration requires the proper amount of steam at the right time. Live steam regulators must be properly sized and controlled. Heavy intermittent loads will require larger regulators than steady loads. Where it is necessary to install a larger regulator for more capacity to handle an occasional intermittent load, a smaller regulator should be installed in parallel with the large one. This will provide better control since the larger one can be shut down during periods of light loads such as the summer season. Large regulators have a tendency to chatter or groove the seat and generally do not control well on very light loads. Regulators of a type to give close control in the pressure range of ½ to 5 psig should be installed. This generally calls for a large diaphragm (12 to 16 inches diameter) or a pilot controlled valve. Regulators should be installed with their outlet as close as possible to the deaerator and the outlet line should normally be increased to larger line size. A long line from the regulator to the deaerator should be avoided as it slows the action of the regulator and gives poor control. The control line on the regulator should be piped directly to the deaerator shell since the pressure to be controlled is in the deaerator, not in the line to the deaerator. Instant action of the regulators is required to ensure that steam is provided instantly, and that deaeration takes place as the water flows into the deaerator. This response can only be obtained if the regulator sensing line actually senses pressure in the deaerator shell proper. Control lines connected close to the regulator or in the line are not effective.

(3) **Venting of Gases.** Gases that are released from the water must be properly vented. Failure to obtain the proper water temperature is often due to insufficient venting. This can be done in two ways: directly to the atmosphere or through a vent condenser to the atmosphere. Venting directly to the atmosphere is effective but results in wasted steam. Venting through a vent condenser is better since much of the heat in the vent steam can be recovered.

Table 4-5. Deaerator Temperature Versus Pressure

Pressure in heater psig	Boiling Points Corresponding to Various Elevations												
	Sea level	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
.0	212*	211	210	209	208	207	207	206	205	204	203	202	201*
.5	214	213	212*	211	210	209	208	208	207	206	205	204	203
1.0	215	215	214	213	212*	211	210	209	208	208	207	206	205
1.5	217	216	215	215	214	213	212*	211	210	209	208	208	207
2.0	219	218	217	216	215	215	214	213	212*	211	210	209	208
2.5	220*	219	219	218	217	216	215	215	214	213	212*	211	210
3.0	222	221	220*	219	219	218	217	216	215	215	214	213	212*
3.5	223*	222	222	221	220*	219	219	218	217	216	215	215	214
4.0	224	224	223*	222	222	221	220*	219	219	218	217	216	215
4.5	226	225	224	224	223*	222	222	221	220*	219	219	218	217
5.0	227	227	226	225	224	224	223*	222	222	221	220*	219	219
5.5	229	228	227	227	226	225	224	224	223*	222	221	222	220*
6.0	231	230	229	228	227	226	225	224	223	222	221	220	219
6.5	232	231	230	229	228	227	226	225	224	223	222	221	220
7.0	233	232	231	230	229	228	227	226	225	224	223	222	221
7.5	234	233	232	231	230	229	228	227	226	225	224	223	222
8.0	235	234	233	232	231	230	229	228	227	226	225	224	223
8.5	236	235	234	233	232	231	230	229	228	227	226	225	224
9.0	237	236	235	234	233	232	231	230	229	228	227	226	225
9.5	238	237	236	235	234	233	232	231	230	229	228	227	226
10.0	240	239	238	237	236	235	234	233	232	231	230	229	228
10.5	241	240	239	238	237	236	235	234	233	232	231	230	229
11.0	243	242	241	240	239	238	237	236	235	234	233	232	231
*Exact	Temperatures are shown to the nearest whole degree												

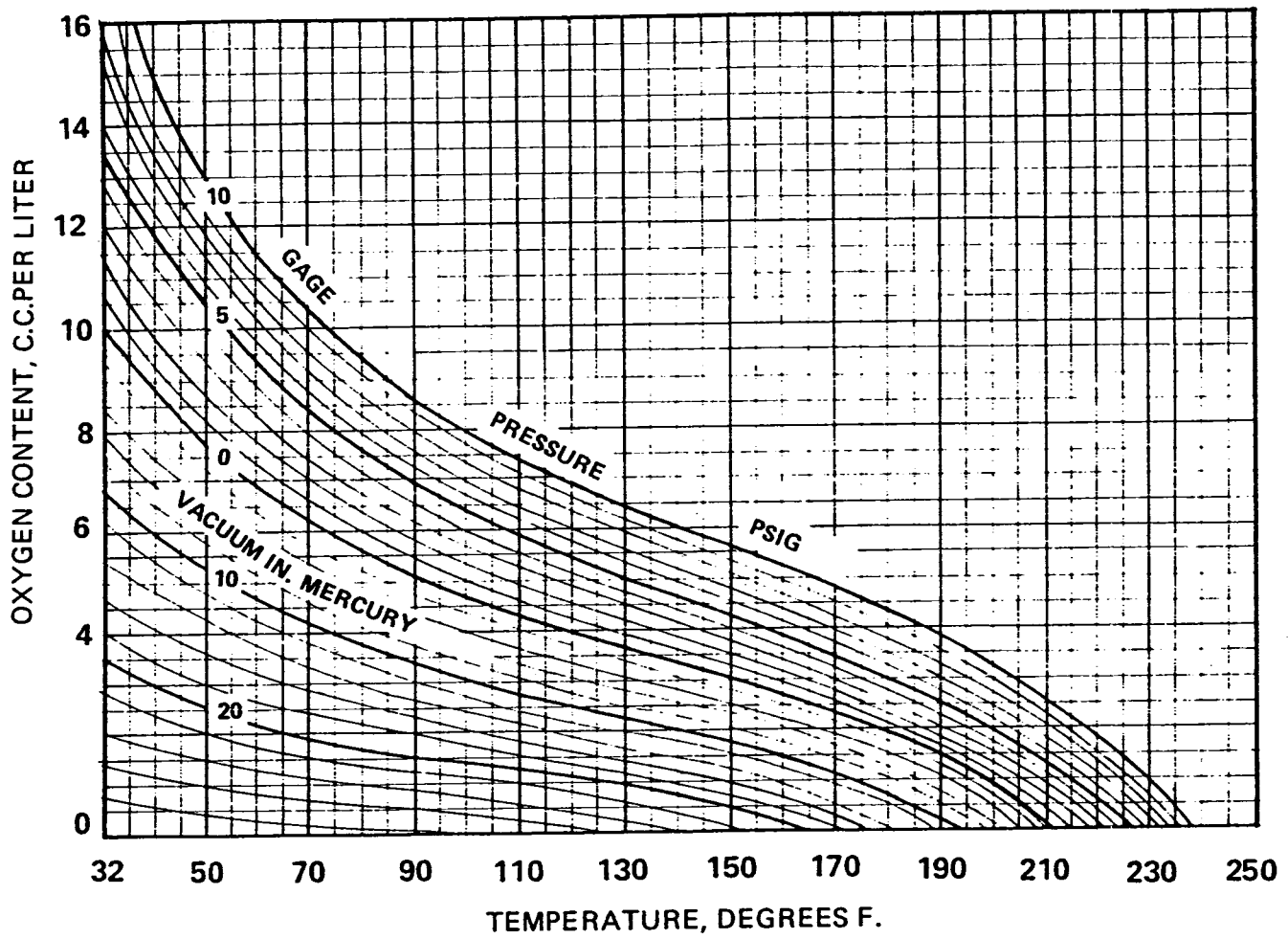


FIGURE 4-27. SOLUBILITY OF OXYGEN IN WATER

Conventional heaters are vented from either the top or sides of the shell. Thermostatic traps should not be used. The best vent for a heater is as 1/2- or 3/4-inch gate valve with an 1/8-inch hole drilled through the seat, permitting positive venting at all times in case the valve is inadvertently closed. The amount of valve opening depends upon load conditions and the size of the heater. Approximately one-tenth to one percent of plant load is usually required to be vented at all times, but the actual amount requires trial and error determinations and a series of oxygen analyses on water from the deaerator. Oxygen content of the water is the final criteria for proper deaeration. Vent lines should be installed to permit visual observation of the amount of venting.

d. Corrections for Improper Deaerator Operation. Operational and mechanical changes to correct deaerator troubles are described below. Changes should be made in a systematic, step by step procedure because more than one of them may correct the adverse condition.

(1) Surge Tank Problems. Surge tank problems may occur where water has a tendency to hold up in the tank.

(a) Install a vacuum breaker on closed surge tanks which are under pressure. This can be a 1 1/2-inch or 2-inch flapper type check valve. Vacuums sometimes are caused when a sudden heavy load of cold condensate or raw water enters the hot surge tank.

(b) Lower the pressure maintained on the deaerator and operate at the lowest pressure required for uniform temperature control.

(c) If the surge tank is constructed for pressures up to at least 15 psig, and if the condensate return pumps discharging to it have sufficient head capacity, an equalizing line may be installed between the top of the surge tank and the deaerator to maintain the same pressure on both. Install a line of ample size to equalize the pressures.

(d) Install a feed line of ample size between the surge tank and the deaerator. Streamline as much as possible the fittings and turns which could retard the flow.

(e) Where headroom permits and condensate return pumps have sufficient head capacity, raise the surge tank to provide at least 3 psi dynamic head difference between the water level in the surge tank and the top of the deaerator. Example: A deaerator operating at 3 psig will require that the surge tank water level be at least $(3 \text{ psig} + 3 \text{ psi}) \times 2.31 \text{ feet per psi}$ or 13.8 feet above the water inlet to the deaerator. Consideration must be given to friction loss in straight piping and fittings, as well as control valves, type of vent condenser, and type of deaerator to arrive at the proper height of the surge tank. Where an equalizing line is used between the surge tank and deaerator, the minimum distance is $3 \text{ psi} \times 2.31 \text{ feet per psi}$, or 6.93 feet.

(f) Where there is insufficient head between the deaerator and boiler-feed pump and it would be

uneconomical to raise the deaerator, install a low-head booster pump between the deaerator and feedwater pumps to prevent vapor binding. Select a pump with adequate capacity and discharge pressure sufficient to maintain 3 psi dynamic head on the suction side of feedwater pumps when at full capacity of the plant.

(2) Lack of Adequate Head on Boiler Feed Pumps. Lack of adequate head between the deaerator and the boiler-feed pumps is one of the most common sources of trouble.

(a) Check the feed pumps for proper packing, valve settings, slippage, etc.

(b) For reciprocating pumps where normal operation uses one pump at a high rate, use two pumps at a lower speed instead. This will give the cylinders more time to fill, thereby decreasing the tendency of the water to flash.

(c) Install a vertical storage chamber on the suction side of the feed pump. This chamber should be constructed of pipe one or two sizes larger than the pump suction and equalized with the heater by running a 1- to 1 1/4-inch line from the top of the chamber to the steam space of the deaerator.

(d) A 1/2- or 3/8-inch line may be run from the top of the water cylinder on the feed pump or bleed cock to the steam space on the deaerator to act as a bleed line for any steam vapor formed. This can be especially useful on centrifugal pumps.

(e) Piping connections between the deaerator and feed pumps should be as direct as possible, of ample size, and at least one size larger than the pump inlet. Any reductions in size should be made at the pump inlet. Avoid numerous fittings and 90° turns.

(f) Lower the operating pressure of the deaerator as much as possible but always operate with some continuous positive pressure, even it is only 1/2 psig. Deaeration is only successful when the temperature is above the boiling point of water, which can only occur if there is a positive pressure on the deaerator.

(g) Where construction permits, give consideration to the possibility of lowering the boiler-feed pumps into a pit or raising the deaerator in order to obtain the necessary head on the pump suction. This should be considered only after all other means of correction have been exhausted.

(3) Feedwater Temperature Fluctuations. If feedwater temperature varies widely from that expected for a given set of conditions, one of the following problems may exist.

(a) The deaerator may be insufficiently or improperly vented.

(b) The thermometer or pressure gage may be inaccurate. Check the instruments periodically for accuracy.

(c) Pressure gage readings must be corrected for

hydrostatic head, if any. Make a correction of ± 0.43 psi for each foot of static head due to a water leg. For example, a gage installed 10 feet below the level of the gage connection to the heater would require a correction of 4.3 psi (6.3 psi gage reading - 4.3 psi = 2 psi in the deaerator). The shell of the deaerator is the most satisfactory location for a gage installation.

- (d) The deaerator may require cleaning.
- (e) The deaerator trays may be misaligned.
- (f) The thermometer bulb may not be submerged in the circulating water. It is important that the bulb be submerged about four inches. If the bulb is out of the water, it will measure steam temperature rather than water temperature and proper control will be impossible.
- (g) The deaerator may not be of sufficient capacity for the amount of water being heated.
- (h) The live steam supply may be insufficient.
- (i) The pressure regulating valve may be misadjusted or improperly sized for close control.

4-17, GENERAL OPERATION OF INTERNAL TREATMENT EQUIPMENT

Boiler water is treated to control corrosion and scale deposits in the boiler and distribution system. Internal treatment chemicals should be maintained within the limits established in paragraph 4-5. Failure to maintain proper treatment levels can result in excessive corrosion and scale, tube failure, leaks, energy losses, and excessive maintenance and operating expenses. The chemicals and feed equipment used in internal treatment are discussed in paragraph 4-8. The feeding procedures and precautions are discussed below.

a. Chemical Feed Equipment. Internal treatment chemicals can be fed into the system through either closed or open feeders. All steam boilers operating above 15 psig should be provided with equipment to add chemicals directly to the boilers. The point of chemical admission varies with the specific chemical, the individual boiler plant, and operating conditions. Use the chemical feed connection provided by the boiler manufacturer, if possible.

(1) **Closed Feeder.** The pressure-pot feeder is a simple chemical feeder that can be fabricated from a piece of 6- or 8-inch pipe 18 to 24 inches long. Both ends are sealed by capping or welding and suitable valving and funnel are installed for admission and discharge. Feeders fabricated in accordance with the ASME code are commercially available. Military Specification MIL-F-18113 shows a pressure-pot feeder which is illustrated in figure 4-28. Before entering the pressure-pot feeder, the chemicals must be mixed or dissolved in a mixing tank. For small installations, the mixing tank may consist of

a steel barrel. A small steam jet in the bottom of the mixing tank can be used to facilitate mixing. Chemicals such as phosphate and tannin can be dissolved in a fine-mesh basket suspended just beneath the surface of the water in the mixing tank. Figure 4-29 illustrates a more elaborate dissolving tank and pressure feeder.

(2) **Open Feeder-Chemical Mixing Tank/Chemical Feed Pump.** For larger chemical dosages it is more convenient to use an open feeder with chemical feed pump as shown in figure 4-30. The use of this arrangement is usually justified for boilers using more than one thousand dollars worth of chemicals per year, because it improves results and reduces chemical costs. The chemical-dissolving tank should be large enough to hold about one gallon of solution for each pound of chemical used per day. Many commercial chemical mixing tanks are made of fiberglass, although for many installations a 55-gallon drum is suitable. Tanks should not be made of galvanized or tinned iron or aluminum. The open feeder has a valved line near the bottom to carry the chemical solution to the pump, a gage glass, agitator, safety relief valve and cover. A screen or dissolving basket is suspended at a point about a foot below the top of the tank. Donut floats should be used when sodium sulfite is being prepared to avoid oxidation of the solution. No direct connection between a potable water supply and the chemical tank is permitted. Figure 4-31 illustrates a plunger/diaphragm type pump which is suitable for chemical feed applications.

b. Feeding Procedure. Chemicals should be fed after making tests for boiler water chemical residuals. If the test for total dissolved solids indicates that blowdown is necessary, blow the boiler down before feeding the chemicals. If certain residuals are low, proceed as follows:

(1) Determine the required amount of treatment chemicals by study of chemical residual test results and boiler operation.

(2) Weigh the total amount of each required chemical.

(3) Dissolve the chemical in the mixing or dissolving tank by adding sufficient water and using a wooden paddle reserved for this purpose.

(4) Allow the solution to flow to the chemical pump (or place it in the pressure-pot feeder) in proportion to the requirements of each boiler.

(5) When only one boiler is involved, all required chemical solutions may be mixed and fed as a single solution.

(6) Where feedwater deaerating heaters or deaerators are installed, feed sodium sulfite continuously to the reservoir of the heater or the deaerator.

c. Feeding Precautions. When feeding chemicals, use the following precautions.

(1) Do not feed any chemical ahead of the feedwater heater or deaerator.

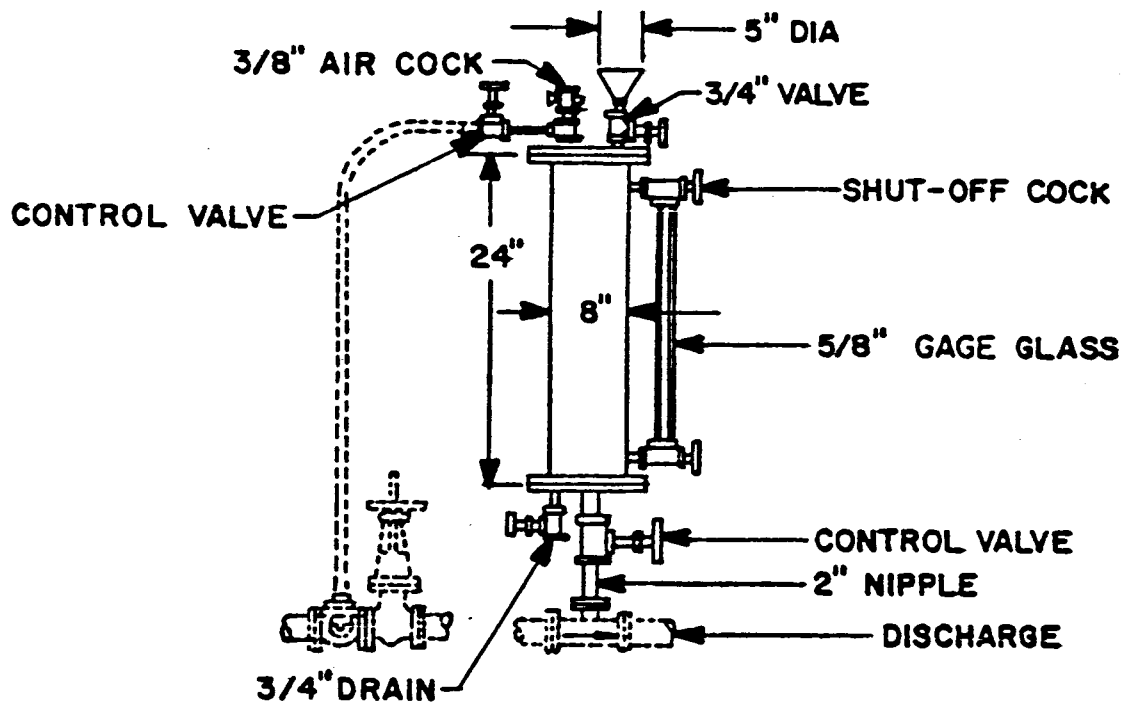


FIGURE 4-28. PRESSURE POT FEEDER

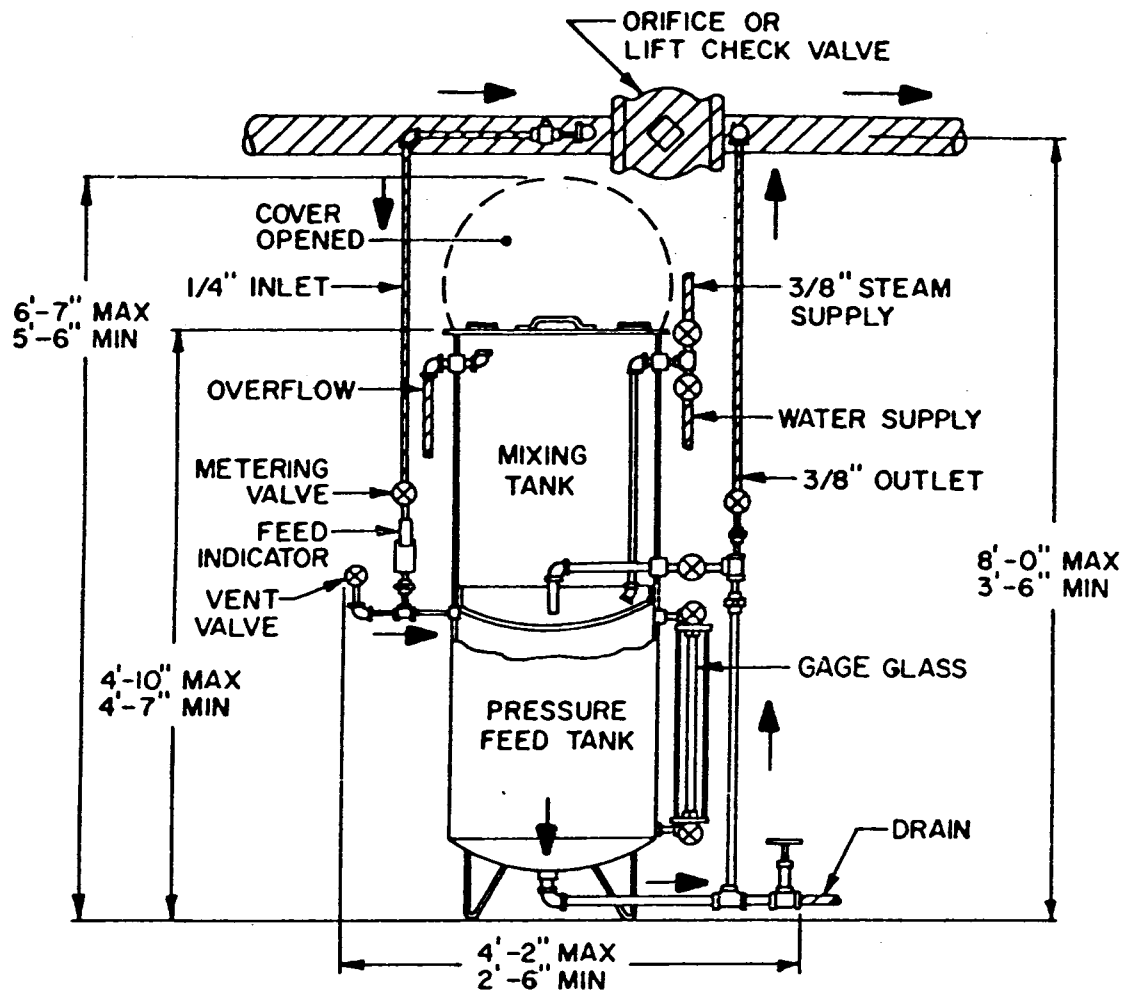


FIGURE 4-29. AUTOMATIC PROPORTIONING FEEDER

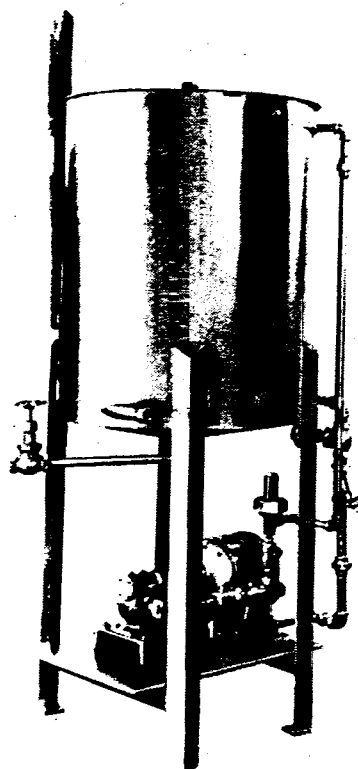
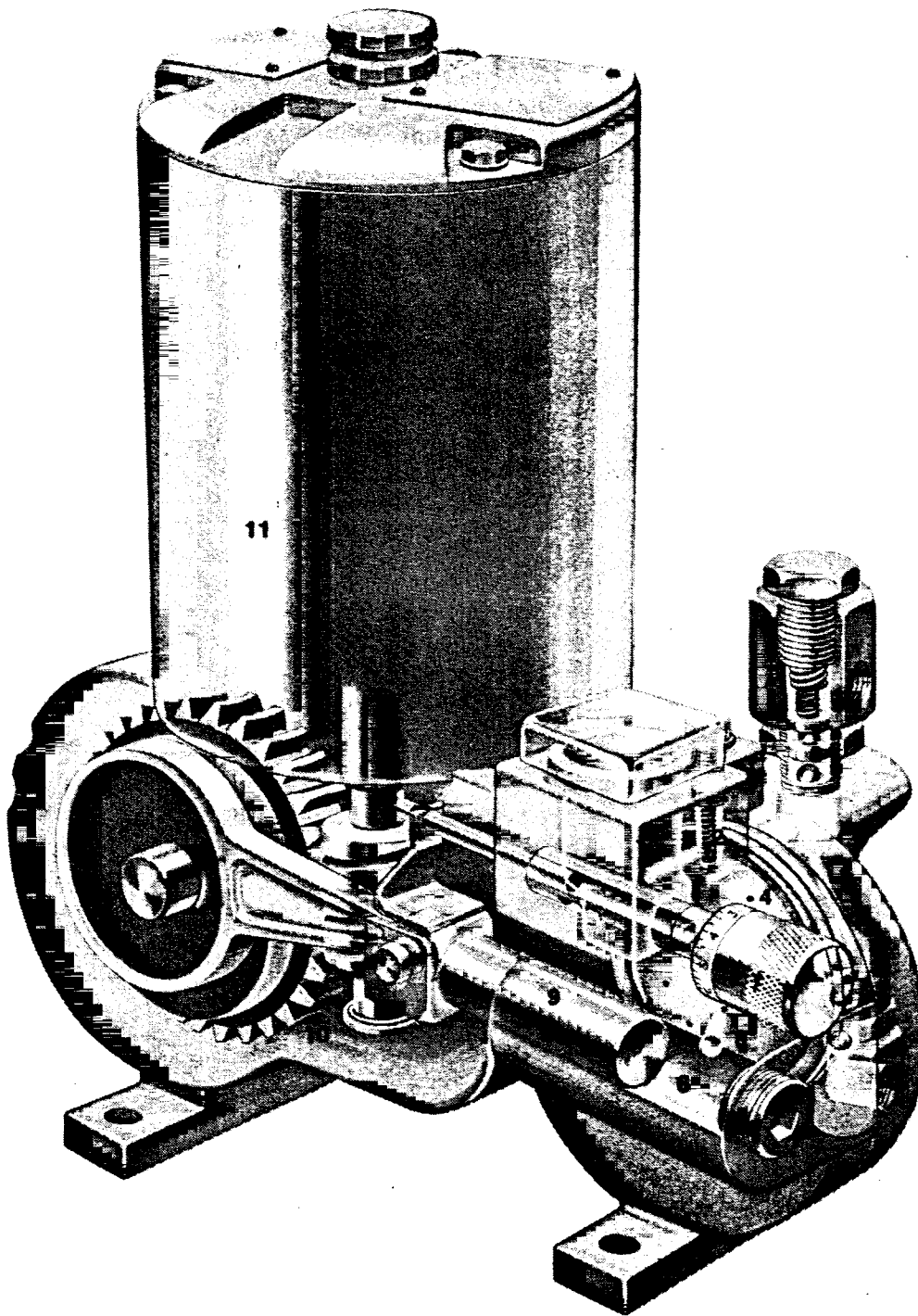


FIGURE 4-30. CHEMICAL MIXING TANK WITH
CHEMICAL FEED PUMP



1. Repetitive accuracy guaranteed by automatic air venting on each pump stroke to prevent vapor accumulation.
2. Built-in relief valve prevents pump damage if discharge system is blocked during operation.
3. Dependable double ball check valves in easily replaceable cartridges for simplified maintenance.
4. Proven Teflon[®] diaphragm design is fatigue-resistant and leakproof under normal operation.
5. Diaphragm head can be remotely located for submerged tank pumping of dangerous liquids.
6. Self-compensating hydraulic system — no vacuum breakers or refill valves to adjust.
7. Positive capacity adjustment over full flow range during operation. Electric or pneumatic capacity adjustment options available for remote or process instrument control.
8. Hydraulically actuated diaphragm is not pressure loaded, acts only as separating membrane between liquids.
9. Precise plunger-bore fit with generous bearing area eliminates plunger packing, extends service life.
10. All moving parts are continuously submerged in lubricating oil to assure long, efficient pump life.
11. Compact design with self-contained totally enclosed motor² and drive allows installation in almost any location or environment.

FIGURE 4-31. CHEMICAL FEED PUMP
PLUNGER/DIAPHRAGM TYPE

(2) Do not feed sodium orthophosphates unless authorized by the operating agency commander.

(3) Do not feed sodium orthophosphate into the feedwater system. Feed it directly into the boiler.

(4) Never place dry chemicals in a chemical feeder or pump. This practice will plug the chemical feed lines in a short time.

(5) Make sure all piping and valve installed with chemical feeders or pumps are designed to withstand the boiler pressure.

(6) Drain the feeder before introducing chemicals. When draining the feeder, close all pressure connections to the feeder before opening the drain valve to prevent injury to the operator by hot water or chemicals.

4-18. SAFETY PRECAUTIONS

The primary requirements for safety in boiler plant water conditioning are the same as those for the operation of any other plant or process: good maintenance, proper procedures, and good housekeeping. If the plant is not kept clean and orderly, the chances for accidents multiply. Treatment of water involves the use of chemicals, some of which are dangerous if not handled properly. All safety data sheets must be thoroughly read and strictly followed.

a. Acids. The tests for chemical residuals involve negligible quantities of acid, and the risk is small if spillage is avoided and bottles containing acid are not broken. Greater risks are involved in the handling of sulfuric acid in the hydrogen zeolite, demineralizing, and direct-acid treatment processes. The Manufacturing Chemists Association has published a Chemical Safety Data Sheet, SD-20, dealing with the methods of handling sulfuric acid. The following excerpt from the bulletin lists some of the recommended precautions.

(1) Do not permit dilute or strong sulfuric acid to come in contact with the eyes, skin, and clothing.

(2) When handling the acid, always wear goggles, face shields, gloves, and protective clothing.

(3) Never add water or caustic solutions to sulfuric acid; violent reactions can take place. Spattering must be avoided. If it is necessary to mix acid and water, always add the acid cautiously to the water; never add water to strong acid.

(4) Cleaning or repairing tanks should be performed under proper supervision of a foreman. Instructions relative to entering and cleaning of tanks and exact steps to be taken must be observed. Emergency equipment must be immediately available before workers are allowed to enter tanks for making repairs.

(5) Wash down spills immediately with plenty of water. Never use combustibles such as cloths, sawdust, or other organic materials for mopping up spilled sulfuric acid.

(6) In the event of accidental contact, all contaminated clothing should be removed immediately and affected areas washed with plenty of water for a least 15 minutes. This is especially important when the eyes are affected.

b. Caustic Soda. The Manufacturing Chemists Association has issued a Chemical Safety Data Sheet, SD-9, on handling caustic soda. The following quotation from it illustrates the need for safety measures. "Caustic soda is dangerous when improperly handled. Whether in solid form or in solution, marked corrosive action results from contact with all tissues of the body. Since signs and symptoms of irritation are frequently not evident immediately after contact with caustic soda, injury may result before one realizes that the chemical is in contact with the body. Therefore, adequate protection against such exposure should be provided for all parts. If such precautions are ignored and carelessness is tolerated, caustic soda is capable of producing serious injury . . ." The same precautionary measures indicated for sulfuric acid also apply to the handling of caustic soda.

c. First Aid. The following safety equipment should be readily available.

(1) **Eyewash Fountain.** Have an eyewash fountain, detailed in figure 4-32, or a ready source of running tap water, such as a bubbler drinking fountain or hose with a soft, gentle flow of water, available for eye irrigation. If even minute quantities of sulfuric acid or caustic soda enter the eyes, irrigate the eyes immediately and flush the eyes with a large amount of water for a minimum of 15 minutes.

(2) **Safety Shower.** Have a readily accessible, well-marked, rapid-action safety shower available in the area where sulfuric acid or caustic soda is being handled. A suggested type is illustrated by figure 4-33.

(3) **Safety Inspection.** Inspect all safety equipment regularly to ensure it is in working condition at all times. Place clearly marked signs near the emergency eyewash fountain and the safety shower to indicate their methods of use.

d. Chemical Spill Kits. Each boiler plant should be equipped with the appropriate chemical spill kits. These kits are commercially available to clean up acids, bases, and solvents. It is best to be prepared for the spill that never happens. The moments after a spill has occurred are not the time to decide how to handle the spill.

4-19. CARE OF IDLE STEEL BOILERS

Serious corrosion, caused by oxygen dissolved in water, can occur while a boiler is idle. If oxygen is permitted to dissolve in even small pools of boiler water, concentrated localized corrosion will result. It is not always possible to eliminate air from the boiler, but it is possible to dry

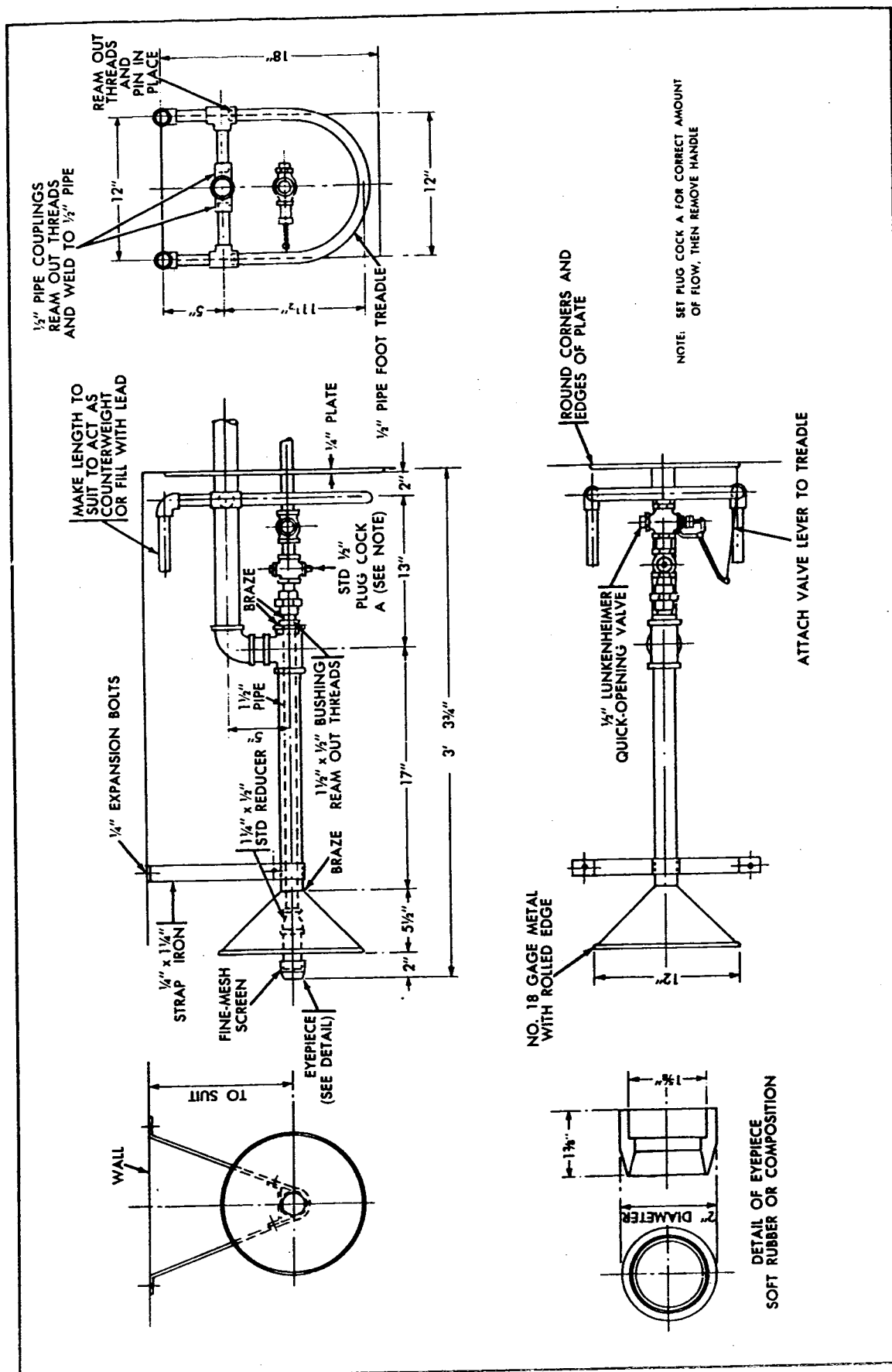


FIGURE 4-32. EYEWASH STATION

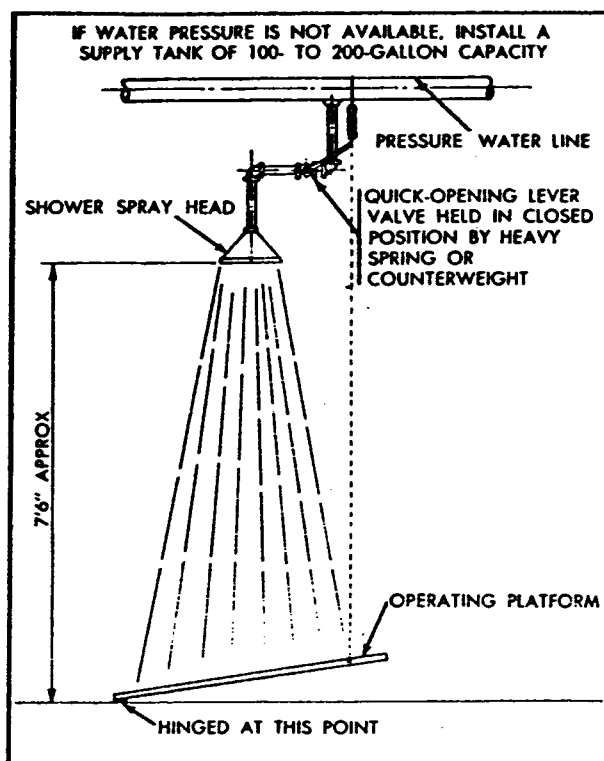


FIGURE 4-33. SAFETY SHOWER

the boiler and follow other procedures which will protect the metal surfaces. Standby boilers may be called upon to resume operation within four to six hours. Under these conditions, it is not practical to drain the boiler and an alternate wet method of boiler layup is recommended. Note that the dry methods should not be used on cast-iron boilers. The following procedures will protect boiler metal against corrosion during out-of-service periods:

One to Three Days. Boilers that will not be used for one to three days should be maintained in a hot standby condition. Steam boilers should have their outlet valves shut. Sludge should be blown down before shutdown. Combustion equipment should be fired as needed to maintain the boiler under pressure. Take care to not allow the boiler to cool and pull a vacuum that would draw air into the boiler and damage gaskets. Normal boiler water treatment limits are maintained.

Four to 30 days. The boiler should be filled with water treated with caustic soda and sodium sulfite. See Procedure a.

Thirty to 150 Days. The boiler should be laid up by either the "wet" or "dry" method. "Wet" see Procedure b. "Dry" see Procedure c or d.

In Excess of 150 Days. The boiler should be laid up by the "quicklime" or "silica gel" method. See Procedure d.

a. Wet Method-Short Periods. Procedure a — Load conditions may make it necessary to shut a boiler down for relatively short periods yet maintain it in a standby condition. Corrosion will result if the normal water level in the boiler is maintained during the standby period. Proceed as follows to avoid corrosion:

(1) Approximately one hour before taking the boiler off line, introduce enough caustic soda and sodium sulfite to increase causticity to approximately 500 ppm hydroxide and to provide 200 ppm sodium sulfite concentration as Na_2SO_3 .

(2) When the boiler is off line, fill it completely with deaerated water or condensate.

(3) Before operation is resumed, drain the water to the proper level and make chemical tests for causticity, phosphate, tannin, and total dissolved solids. Blow down the boiler or feed chemicals as indicated by the test results.

b. Wet Method. Procedure b — If a boiler is not on standby service the following wet layup method is recommended:

(1) Drain the boiler completely. Ensure that water walls and gage columns are not overlooked. Next, open the boiler and wash the inside of loose scale and sediment by flushing thoroughly with strong water pressure. Use a stiff brush to clean all internal surfaces of the boiler that can be reached. Break the feedwater and steam connections to the boiler and blank the connections if other

boilers in the plant are operating.

(2) If the boiler plant is equipped with a deaerator, fill the boiler with deaerated water. If no deaerator is installed, use either condensate or raw water for this purpose. While the boiler is being filled, add enough caustic soda to give a hydroxide content of 500 ppm in the boiler water (about eight pounds of caustic soda per thousand gallons holding capacity of the boiler), and enough sodium sulfite to give 200 ppm concentration (about 2 pounds of sodium sulfite per thousand gallons holding capacity of the boiler).

(3) Start a small fire in the furnace. Open the vent or safety valve and boil the water within the boiler under atmospheric pressure for two hours to ensure circulation of chemicals and deaeration. When the water in the boiler has cooled, fill the boiler to the top, overflowing the vent or safety valves to ensure complete filling.

(4) Make periodic inspections to ensure maintenance of water level. Replace any water lost from the boiler. It may be necessary under these conditions to add additional chemicals to the boiler. Maintain hydroxide and sodium sulfite concentration at about 500 ppm and 200 ppm, respectively.

(5) To facilitate inspections, a small steel tank equipped with a gage can be installed above the top of the boiler, as shown in figure 4-34. This tank can be filled with water and connected to a steam takeoff tap, vent, or safety valve connection. A glance at the water level in the small drum will quickly tell whether or not the boiler is completely filled.

c. Dry Method. Procedure c — Boilers equipped with manholes may be laid up for 30 to 150 days using the dry method described below.

(1) Take the boiler out of service and drain it completely while still warm. Ensure that water walls and gage columns are not overlooked. Next, open the boiler and wash the inside of all loose scale and sediment by flushing thoroughly with strong water pressure. Use a stiff brush to clean all internal surfaces of the boiler that can be reached. Break the feedwater and steam connections to the boiler and blank connections if other boilers in the plant are operating.

(2) If the boiler room is dry and well-ventilated, the boiler may be left open to the atmosphere. If not, use Procedure d.

d. Quicklime or Silica-Gel Method. Procedure d — This method applies only to boilers equipped with manholes.

(1) Take the boiler out of service and drain completely while still warm. Check to ensure that water walls and gage columns are not overlooked. Next, open the boiler and wash the inside of all loose scale and sediment by flushing thoroughly with strong water pressure. Use a stiff brush to clean all internal surfaces to the boiler and blank

the connections if other boilers in the plant are operating.

(2) Start a very light fire in the furnace. Maintain this fire for at least two hours or until inspection shows no moisture on internal sections of the boiler.

(3) Place quicklime (**not hydrated lime**) or silica-gel in one or more metal or fiber trays in the boiler. Place the trays on wood blocks so that air can circulate beneath them. The amount of lime or silica-gel required is about 50 pounds per 3,000 pounds of steam per hour boiler capacity.

NOTE

It is important that the quicklime or silica-gel does not contact the metal surface of the boiler.

(4) Seal the boiler tightly.

(5) Open and inspect the boiler every two months. Carefully reseal immediately after the inspection. If the lime or silica-gel is found to be wet upon inspection, replace it with dry material.

(6) To resume operation, reopen the boiler, remove the trays of quicklime or silica-gel, reseal all drumheads and manholes, and replace all piping removed and blanked.

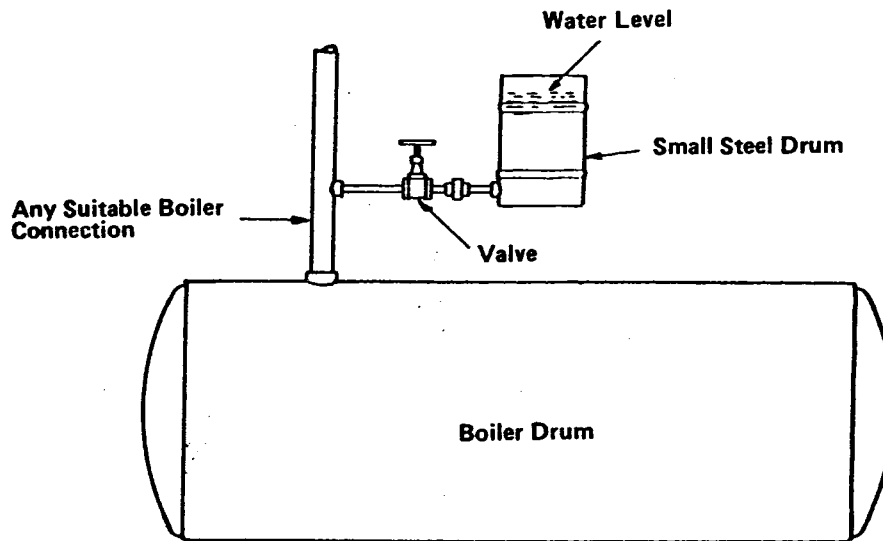


FIGURE 4-34. WET STORAGE METHOD